C **Unit 11** C{PRIVATE }

Waste Minimization

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WASTE MINIMIZATION

Reducing the amount of hazardous waste produced is the only permanent and practical solution to the myriad of problems caused by hazardous waste. Additionally, waste reduction makes economic sense; today's generators are tomorrow's potentially responsible parties with legal liability even if current regulations are followed. This unit presents an overview of the basic principals of waste minimization.

11.1 DEFINITION

Waste minimization means the reduction, to the extent feasible, of any solid or hazardous waste that is generated or subsequently treated, stored, or disposed of in some manner. In practice, waste minimization is broken down into two basic activities:

! **source reduction**Cin-plant changes that either reduce or eliminate the generation of hazardous waste; and
! **recycling**Creuse of a wastestream as an ingredient in a productive process or recovery of a reusable product from the waste.

Source reduction is usually preferable to recycling from an environmental perspective. Recycling is less desirable because the generation of waste still occurs and the recycling process results in waste residues.

The present focus of waste minimization activities is on hazardous waste, as defined by RCRA. However, it is important that all pollutants emitted into air, water, and land be considered as part of a waste minimization program.

The transfer of pollutants from one medium to another does not constitute waste minimization. For example, the removal of organics from wastewater using activated carbon is not waste minimization because the pollutants are merely transferred from one medium (wastewater) to another (carbon).

11.2 REGULATIONS

Waste minimization is a policy specifically mandated by the U. S. Congress in the 1984 Hazardous and Solid Wastes Amendments (HSWA) to the RCRA. This mandate, in part, states that:

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> *The Congress hereby declares that it is to be a national policy of the United States that, where feasible, the generation of hazardous waste is to be reduced or eliminated as expeditiously as possible.*

In addition, as of September 1985, generators of hazardous waste are required to certify on manifests that:

> *If I am a large quantity generator, I certify that I have a program in place to reduce the volume and toxicity of waste generated to the degree I have determined to be economically practicable ...or, if I am a small quantity generator, I have made a good faith effort to minimize my waste generation and select the best waste management method that is available to me and that I can afford.*

The Pollution Prevention Act of 1990, established as the national policy of the United States, states that whenever feasible, pollution should be prevented or reduced at the source. Pollution that cannot be prevented at the source should be recycled in an environmentally safe manner. If the pollution cannot be prevented or recycled, it should be treated in an environmentally sound manner, and disposal should be employed only as a last resort.

Several Executive Orders have been issued that specifically require federal agencies to comply with pollution prevention, waste minimization and recycling. Executive Order 12780 of October 31, 1991 (Federal Agency Recycling and the Council on Federal Recycling and Procurement Policy) and Executive Order 12873 of October 20, 1993 (Federal Acquisition, Recycling, and Waste Prevention) require federal agencies to promote cost-effective waste reduction and recycling of reusable materials from waste generated by federal government activities.

Unfortunately, neither HSWA or subsequent regulation defined what constitutes a waste minimization program. The law only requires that a program be established and that waste minimization be evaluated.

Economic incentives more than compensate for what is lacking in regulations. Short-term costs of waste disposal have increased dramatically in recent years and will continue to increase. Potential long-term waste disposal costs, due to environmental impairment

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liability under CERCLA, cannot be estimated and have no financial ceiling. Therefore, these short-term disposal costs and long-term liability exposure have combined to make waste minimization attractive economically.

11.3 SOURCE REDUCTION METHODS OF WASTE MINIMIZATION

11.3.1 PURCHASING CONTROLS

In the past, the basic purchasing consideration for chemicals was cost; no thought was given to expenses and liability incurred during disposal. As a result, chemicals were often purchased in large quantities and various brands were purchased to take advantage of sales. This practice created hazardous waste disposal problems that can be solved by following some of the following suggestions.

- Require supervisor approval prior to purchasing hazardous chemicals. This forces the worker to think twice before requesting that a hazardous chemical be purchased and it makes management aware of when and how much chemicals are being added to the inventory.
- Keep the inventory of hazardous chemicals to a minimum. This will assist in container rotation and reduce shelf-life problems. In addition, when less product is available, workers generally use less.
- Reduce the number of brands or products used for the same purpose. While everyone has a favorite brand, numerous brands of the same product increase shelf-life problems.
- Buy only what will be used within a short period of time. Although small quantities cost more to purchase, a reduced inventory decreases use and saves disposal expenses.

For example, a mineral research company was preparing to move to another facility. While cleaning out a store room, approximately 23 drums of unused chemicals were discovered. Some of the chemicals dated back 18 years, and all had to be disposed of because of expired shelf life. The new facility instituted a strict purchasing, rotating, and inventorying program that prevented the generation of hazardous waste due to poor product management.

11.3.2 IMPROVED HOUSEKEEPING

Sloppy housekeeping, such as leaking tanks, pumps, and valves, and release of process chemicals on the floor, can dramatically increase the volume of hazardous waste. Other practices, such as tank overflows, a lack of drip boards, and chronic spills add to the hazardous

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waste stream. Not only is valuable product lost, but the volume of waste generated increases, especially when water or other substances are used during cleanup. Other housekeeping problems involve improper storage practices, inefficient production startup and shutdown, scheduling problems, and poorly calibrated control devices.

For example, a Colorado company using blister packing prior to shipping generated considerable waste when one product rolls ran out and another had to be threaded into the machine. The waste was eliminated when an alarm was installed that shut off the machine when the product roll was about to run out. The operator then taped the new roll to the old one, thus preventing a break that invariably necessitated a substantial amount of lead-in waste.

In Michigan, an auto plating shop carefully pretreated parts prior to placing them in a plating bath. As a result of the pretreating, the plating bath did not need to be drained during 27 years of operation. Most other auto plating shops drained planting tanks once a year at an approximately cost of $25,000 per shop.

Good housekeeping can solve a variety of hazardous waste generation problems. In addition, housekeeping changes can usually be implemented quickly and with little cost.

11.3.3 PRODUCTION CHANGES

Outdated equipment and traditional production methods can generate large volumes of hazardous waste, especially when production is the goal and waste generation is largely ignored. Although the capital investment to purchase new or different production equipment can be high, the investment is often wise because of even higher disposal and liability costs.

For example, a manufacturing company now uses a water-based electrostatic paint system instead of a conventional organic solvent system. The new system has improved quality of application, decreased downtime, reduced the generation of aromatic waste by 95 percent, reduced paint sludge by 97 percent, and resulted in up to 95 percent recovery and reuse of paint.

A Texas chemical manufacturer recently developed a new process that improved product yield while reducing aqueous waste by 50 percent. In addition, the new process collected waste solvents that were burned

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in the company's powerhouse. The steam generated by the burning of the waste solvents saved the company more than $10 million per year in fuel oil.

11.3.4 PRODUCT SUBSTITUTION

Substituting a non-hazardous chemical for a hazardous one has obvious benefits for waste minimization. Frequently, the new process is also more efficient.

For example, the Department of Defense developed Plastic Media Blasting to strip paint from military aircraft. In this process, small plastic beads are air blasted at the aircraft's surface, removing the paint by mild abrasion. This method requires less time and generates substantially less hazardous waste than the traditional wet stripping. Plastic Media Blasting is quickly becoming the standard method of paint removal for both government and private facilities.

In Los Angeles, the city Transportation Department found than an aqueous cleaner can be substituted for the hydrofluoric acid cleaner used for road signs. They also replaced the oil-based road paint with a thermoplastic product.

11.3.5 WASTE SEGREGATION

Many wastes are actually mixtures of hazardous and nonhazardous waste, such as solvent and water. When this happens, regulatory definition places the entire waste stream in the hazardous waste category, regardless of the contribution made by the actual hazardous waste. By segregating key toxic constituents, isolating liquid fractions, and keeping hazardous streams from nonhazardous waste, generators can save substantial amounts of money on waste disposal.

Waste segregation can also assist in recycling. An unsegregated waste stream may be too costly to recycle because of the large component of nonrecyclable waste. Also, waste separation may not be possible because of similar boiling points or other limitations when the waste is processed during recycling.

For example, an electronics facility in New York purchased a still to recycle waste heptane. However, product specification could not be achieved because other solvents in the waste stream were carried over during the distillation process. The problem was easily solved by separating the heptane waste streams from other solvent waste streams prior to distillation.

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11.4 RECYCLING AND REUSE METHODS OF WASTE MINIMIZATION

11.4.1 RECYCLING

Both on-site and off-site recycling programs are available for a variety of waste products. Probably the most commonly recycled hazardous waste are organic solvents. These wastes can often be recycled by distillation, and small recovery units that handle 55 gallons at a time are commercially available. The pay-back time for such units in often less that one year.

In some cases, simple filtration will allow the waste stream to be recycled. This methods is used in machining operations where cuttings oils are contaminated with metal shavings that can be removed by filtration.

Off-site recycling is commercially available, especially for organic solvents. The recycler picks up the waste from the generator, treats it, and returns it to the generator. This process, called tolling, is available in most metropolitan areas. In some cases, portable recycling units are brought to the generator and the recycling takes place on-site.

For example, a Pennsylvania die manufacturer uses trichloroethylene to clean and degrease machine parts. After installing a solvent recovery unit, the cost of recycling the solvent is only 10% of the previous disposal cost. In addition, the company's purchase of virgin trichloroethylene has decreased by 85%, a savings of nearly $5,000 per year.

In another case, a California city recently implemented a solvent recycling program for its maintenance shops and will soon add an ethylene glycol recycling unit. The sanitation department now recycles all hexane and freon solvents and segregates other solvents for off-site recycling.

11.4.2 REUSE

The best example of hazardous waste reuse is waste exchange.

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Waste exchange is a matchmaking operation based on the premise that one company's waste may be another company's feedstock. The goal of waste exchange is to minimize waste disposal expenses and to maximize the value of reusable manufacturing byproducts.

There are two basic types of waste exchanges: information exchanges and material exchanges. Information exchanges act as a clearinghouse for information on the wastes that are wanted. Most information exchanges are nonprofit organizations that receive funds from governmental agencies. In contrast, material exchanges take actual physical possession of the waste and may initiate or actively participate in the transfer of waste from generator to user. Material exchanges are usually private companies.

While any type of waste can be listed in a waste exchange, most transactions involve relatively pure waste that can be use directly with little or no processing. Solvents, organics, acids, and alkalies are most frequently exchanged. In addition, metals from metal-bearing wastes also may be recovered economically and are commonly transferred in a waste exchange.

11.5 ELEMENTS OF A WASTE MINIMIZATION PROGRAM

Based on an analysis of waste minimization programs, there are seven elements that are common to most successful programs. These elements are as follows.

11.5.1 TOP MANAGEMENT SUPPORT

Support for a waste minimization program must be provided at a sufficiently high management level to influence production and environmental policy decisions. This support can be provided in the form of written policies, designation of responsible persons, and allocation of needed resources to develop a program.

11.5.2 IMPLEMENT MOTIVATION FACTORS

A variety of motivating factors have been successfully used to accomplish waste minimization objectives. In addition to management support mentioned above, motivating factors can include:

- reward and recognize successful waste minimization efforts;
- involve operations personnel in planning and implementation;
- select a program leader that enthusiastically supports waste minimization;

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- integrate waste minimization with quality improvement;
- use the simplest means available to accomplish minimization objectives;
- process modification should be simple to operate, reliable, and easy to maintain;
- provide employee training in how to recognize waste generation and how to identify possible corrective measures; and
- provide adequate funding to implement a waste minimization program.

11.5.3 WASTE CHARACTERIZATION

Before waste can be minimized, it must be identified and characterized in terms of types, amounts, and constituents.
Waste production should be measured and listed by individual production units. Priority should be placed on minimization of wastes that pose the greatest risk to human health or the environment.

11.5.4 WASTE TRACKING

Periodic assessments should be implemented that track materials from initial receipt through usage and waste generation. This assessment can identify ways to reduce or eliminate wastes.

11.5.5 COST ALLOCATION

Successful waste minimization requires that unit production personnel know the true cost of hazardous waste disposal and consider these costs when making management decisions. A cost accounting system that charges individual operating units for compliance, oversight, and insurance costs attributed to waste management has proven to be highly effective in minimizing wastes.

11.5.6 TECHNOLOGY TRANSFER

Successful programs make use of ideas and techniques developed through interactions with other companies, trade associations, technical assistance programs, or professional consultants. Brainstorming to identify potential techniques and demonstration projects should be encouraged.

11.5.7 PROGRAM EVALUATION

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Periodic examination of the waste minimization program must be conducted if program effectiveness is to be adequately measured and objectively evaluated for further improvement.

11.6 STARTING A WASTE MINIMIZATION PROGRAM

11.6.1 PLANNING AND ORGANIZATION

The first step in formulating a waste minimization program is obtaining management commitment. The management of a company will support a waste minimization program if it is convinced that the benefits of such a program will outweigh the costs. Benefits include economic advantages, compliance with regulations, reduction is waste disposal liabilities, improved public image, and reduced environmental impact.

The organization of a waste minimization task force is the next step. This task force should include a "champion," management personnel, production managers, process engineers, and line employees. Individuals that actually generate waste are excellent candidates for the task force because of their knowledge of processes and capabilities as they relate to waste generation and reduction.

Waste minimization goals that are consistent with management policy must be set. Goals can be qualitative, such as a significant reduction of hazardous substances into the environment. However, it is better to establish measurable, quantifiable goals, since qualitative goals can be interpreted ambiguously. Quantifiable goals establish a clear guide as to what the program is expected to accomplish.

Program goals should be reviewed periodically, particularly as the waste minimization program becomes more defined, thus necessitating a modification in the goals. In addition, waste minimization assessments are not intended to be a one-time project. Periodic reevaluation of goals is needed due to changes in technology, economics, regulations, etc.

11.6.2 ASSESSMENT

The purpose of the assessment phase is to develop a comprehensive listing of waste minimization options, to identify the more feasible options that will receive further analysis in the next phase.

One of the first tasks of the assessment phase is to identify and characterize the facility waste streams. Some of this information can be obtained from hazardous waste manifests, reports to regulatory agencies, permits, production composition and batch sheets, product inventory logs, operator data logs, etc. Flow diagrams should be prepared to identify important process steps and to identify sources of

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waste generation. Material balances are also important because they allow for quantifying losses or emissions that were previously unaccounted. Material balances should be prepared for all components that enter and leave the process.

Prioritization of waste streams for waste minimization may be necessary when available funds and/or personnel are limited. The assessment process should concentrate on the most important waste problems first, and then move on to the lower priority problems as time and resources permit. Items commonly addressed in prioritizing waste streams include regulatory compliance, cost of waste treatment and disposal, environmental and safety liability, quantity, hazardous properties, and potential for minimization.

A facility inspection by the task force is the next step. This inspection should followed an agenda and should be scheduled to coincide with the particular operation that is of interest, such as process bath dumping. The operation should be monitored at different times when waste generation is highly dependent on human involvement. During the inspection, operators, shift supervisors, and foreman involved in the operation under inspection should be interviewed. Housekeeping aspects of the operations should be observed. Finally, organization structure and administrative controls should be investigated.

Once the origins and causes of waste generation are understood, the assessment process enters the creative phase. The objective of this step is to generate a comprehensive set of waste minimization options for further consideration. Identifying potential options relies both on the expertise and creativity of the team members. The process for identifying options should follow a hierarchy in which source reduction options are explored first, followed by recycling options.

The last step in the assessment phase is to screen the options and select those options that warrant further study. This screening process serves to eliminate suggested options that appear marginal, impractical, or inferior without a detailed and more costly feasibility study. The results of the screening activity are used to promote the successful options for technical and economic feasibility analysis, the next step.

11.6.3 FEASIBILITY ANALYSIS

The final product of the assessment phase is a list of waste

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minimization options for the assessed area. The assessment will have screened out the impractical or unattractive options. The next step is to determine if the remaining options are technically and economically feasible.

The technical evaluation determines whether a proposed waste minimization option will work in a specific application. Typical technical evaluation criteria include worker safety, maintenance of product quality, space, compatibility with existing operations, labor requirements, installation procedures, and system maintenance.

The economic evaluation is carried out using standard measures of profitability, such as payback period, return on investment, and net present value. Capital investment criteria include such costs as site development, process equipment, materials, utilities, construction and installation, permitting, costs, contractor's fees, start-up time, and training. Operating costs and savings must also be analyzed and may include reduction in waste management and disposal costs, material cost savings, insurance and liability savings, changes in costs associated with quality, changes in utilities costs, changes in operation and maintenance, and changes in revenues from increased (or decreased) production.

While the profitability is important in deciding whether or not to implement an option, environmental regulations may be even more important, A company operating in violation of environmental regulations can face fines, lawsuits, criminal penalties for managers, and even shut down. Therefore, decisions should not be based on profitability alone.

11.6.4 IMPLEMENTING WASTE MINIMIZATION OPTIONS

The assessment and feasibility analyses provide the basis for implementation. Because projects are not always sold on their technical merits alone, a clear description of both tangibles and intangible benefits can help edge a proposed waste minimization project past competing projects for funding.

Obtaining funding may be difficult, especially when capital resources may be prioritized toward enhancing future revenues rather than toward cutting current costs through waste minimization. Having well documented technical facts and knowing the level within the organization that has approval authority for capital projects will assist in obtaining funds.

After the waste minimization option has been implemented, its effectiveness must be measured. One measure of effectiveness for a waste minimization project is the project's effect on the organization's

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cash flow. The project should pay for itself through reduced waste management costs and reduced raw materials costs. The easiest way to measure waste reduction is by recording the quantities of waste generated before and after a waste minimization project has been implemented. However, this simple measurement ignores other factors that also affect the quantity of waste generated, such as the ratio of waste generation rate to the production rate.

Finally, waste minimization is not a one-time effort, but a continuing management system. Once the highest priority waste streams have been assessed and minimization projects implemented, the assessment program should look to areas and waste streams with lower priorities. In addition, to be truly effective, waste minimization must be an integral part of the company's operations.

11.7 ADDITIONAL READING

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